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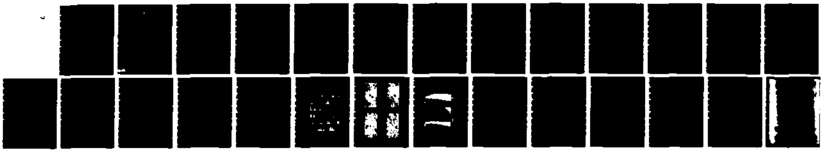

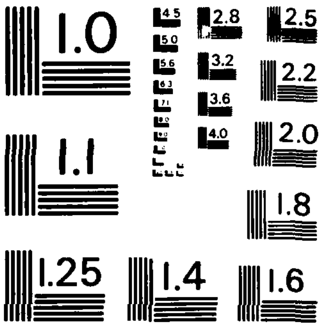

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REPORT

MRL-R-914

MARINE FOULING AT HMAS STIRLING, WESTERN AUSTRALIA

Ian Dunstan

Approved for Public Release

JANUARY, 1984

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This publication details the results of a study of marine fouling at the Naval Support Facility, HMAS STIRLING in Careening Bay, Western Australia. Marked seasonal variation in the settlement of fouling organisms was noted, with the heaviest settlement of most species coinciding with the high water temperatures of the summer months. The fouling community developed in several stages dependent upon temporal variations in settlement and growth of organisms. Established fouling underwent annual changes due to the heavy annual summer settlement of numerous species, the late winter influx of *Mytilis edulis* and the periodic fall-off of large mature organisms. The dominant marine fouling species at HMAS STIRLING were different to those prominent in the fouling at the east Australian Naval establishments.

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ABSTRACT

This publication details the results of a study of marine fouling at the Naval Support Facility, HMAS STIRLING in Careening Bay, Western Australia. Marked seasonal variation in the settlement of fouling organisms was noted, with the heaviest settlement of most species coinciding with the high water temperatures of the summer months. The fouling community developed in several stages dependent upon temporal variations in settlement and growth of organisms. Established fouling underwent annual changes due to the heavy annual summer settlement of numerous species, the late winter influx of *Mytilis edulis* and the period fall-off of large mature organisms. The dominant marine fouling species at HMAS STIRLING were different to those prominent in the fouling at the east Australian Naval establishment.

CONTENTS

ESTABLISHMENT AND DEVELOPMENT OF A MARINE FOULING COMMUNITY AT HMAS STIRLING, WESTERN AUSTRALIA

1. INTRODUCTION

The character and intensity of marine fouling varies greatly with geographic, environmental and seasonal factors [1]. Until recently, information on marine fouling in Australian waters was restricted to studies in the Sydney area [2-6]. An increased awareness of the need for information from other regions has led to reports on the marine fouling in tropical North Queensland [7,8], Hobsons Bay [9], Williamstown Naval Dockyard, Victoria and Garden Island Naval Dockyard, New South Wales [10], and Careening Bay, Western Australia [11-13].

This report details the results from a study of the marine fouling at the Naval Support Facility HMAS STIRLING in Careening Bay, Western Australia.

Little previous information exists on fouling along the West Australian coast. As part of an investigation into the Cockburn Sound ecosystem [11], marine fouling was surveyed on the Garden Island Causeway, which runs adjacent to Careening Bay (Fig. 1). While this study yielded information on the composition of the fouling community on various underwater structures two to nineteen months old, it did not supply data on the seasonal settlement of organisms or the developmental stages of fouling at any one specific site. Chalmer [13] used controlled field experiments to investigate the role of different settlement patterns on the succession of the fouling community at Garden Island.

The present study provides information on the seasonal variation in settlement and the development of the fouling community at HMAS STIRLING. A previous report [12] detailed the results obtained from the first 18 months of investigation. The present report presents the results and conclusions from the full three year investigation.

2. STUDY AREA AND METHODS

Test panels were immersed for fixed times on a frame suspended three metres below Submarine Wharf at HMAS STIRLING in Careening Bay, Western Australia (Fig. 1). The area has a temperate climate and the seawater at HMAS STIRLING has a temperature range from 15°C in winter to 26°C in summer [14]. Conditions in Careening Bay are marine. The frame was shaded by the wharf.

Black unplasticised poly(vinyl chloride) (PVC) panels, (30 x 15 x 0.3 cm), were sandblasted, numbered and weighed prior to immersion. Fouling was studied from October 1976 to October 1979. Seasonal settlement of fouling organisms was monitored by a series of thirty-six panels, each exposed for one month. A second series monitored the long-term development of the fouling community and consisted of twenty-four panels which were immersed at the start of the trial (October 1976). Individual panels were removed at monthly intervals for the first twelve months and at two-monthly intervals thereafter. Assessment of the fouling that developed over a twelve month period was repeated in each of the two subsequent years, although only four panels, removed at three monthly intervals, were used for each year.

All organisms on the panels were identified, to species level where possible, and recorded. Several taxa were not identified below suborder and may contain more than one species. Total species numbers are therefore approximate. Species densities were assessed by counting either individuals or colonies occurring in two 13 x 3 cm transects situated 7 cm from the top and bottom of each panel. A 1 cm strip around the edge of the panel was not assessed to remove possible anomalies towards the edge of the panel. Species density was expressed as number of individuals, or colonies, per 100 cm^2. Density counts for the monthly immersion series and short-term (12 month) successional series were made separately for the front and back of the panels, and the values averaged. The large abundance of organisms and complexity of the fouling assemblage on the later panels of the long-term successional series (13 to 36 months) precluded accurate numerical counts of species densities. Consequently, for all but the large prominent organisms, such as the mussel *Mytilus edulis*, species on these panels were recorded only as present or absent. The wet and dry (panel oven-dried at 80°C to constant weight) weight of fouling on the panels were measured.

3. RESULTS

The first four monthly panels and the thirteenth panel from the long-term successional series were lost by the courier service in transit from HMAS STIRLING to our laboratories. Fouling data for these times are therefore not available.

One hundred and fifteen animal species representing ten phyla were collected from the panels. Seventy-nine of the species were sedentary and thirty-six were errant organisms. Errant species were generally present in small numbers and contributed minimally to the community biomass. A list of

the twenty-seven most common sedentary fouling organisms collected during the study is given in Table 1.

3.1 Seasonal Settlement Series

The number of sedentary species collected from monthly immersion panels showed large seasonal variation with few species settling in the winter months and increased settlement during spring and summer (Fig. 2). Individual settlements of six of the abundant species also showed seasonal variation typified by reduced winter settlement (Fig. 3).

3.2 Community Development Series

Initial settlement on the freshly exposed fouling panels consisted of spirorbid tubeworms, primarily *Janua pagenstecheri* and several compound ascidians (Fig. 4A). A large influx of other species, primarily the barnacle, *Balanus trigonus* and tubeworm *Filograna implexa,* followed in later summer/early autumn. Recruitment of sedentary species was minimal during winter (Fig. 2), although the appearance of the community changed as the larger forms grew and became more conspicuous. The jingle shell, *Anomia trigonopsis,* erect bryozoans, *Tricellaria* sp. and *Bugula stolonifera,* solitary ascidian *Microcosmus claudicans* and encrusting bryozoan *Rhamphostomella*? sp. grew over the early colonisers and dominated the panels during winter (Fig. 4B). Settlement of the mussel, *Mytilus edulis* occurred in late winter (Fig. 5) and individuals grew to cover large areas of the fouling community (Fig. 4C). The number of sedentary species stabilised at around thirty per panel (Fig. 6, curve A) and an increase in biomass of the community (Fig. 7, curve A) resulted from the growth of established organisms.

During the summer of 1977/78 a resurgence in the abundance of many species occurred as the spat of organisms settled on the surfaces of large *Anomia* and *Mytilus* individuals. The number of sedentary species increased slightly and the biomass of the community increased until July 1978 (22 months immersion) when a marked reduction coincided with the appearance of several bare patches on the panels. *Mytilus* byssal threads and *Anomia* bases on these patches indicated that some of the population of these species had been lost from the community.

A peak in *Mytilus* abundance resulted from the 1978 winter spatfall (Fig. 5), however recruitment was small and few individuals persisted. Numerous *Mytilus* remained from the original settlement however, and had reached a length of around 5 cm after 14 months growth (Fig. 4D). Species numbers increased during the summer of 1978/79 and reached a peak of 43 species after 28 months immersion (Fig. 6, curve A). The growth of these newly settled organisms resulted in an increased community biomass (Fig. 7). A large *Mytilus* influx occurred in late winter (Fig. 5). Biomass and species numbers fell during the final months of the study.

The thirty-six month fouling community consisted of a mosaic of fouling growth of different ages. Numerous patches on the panel that had lost

established fouling organisms had been recolonised during subsequent settlement periods. Several large *Anomia, Mytilus* and *Ostrea* individuals that had persisted from the initial colonisation where also heavily encrusted with secondary fouling growth. Several solitary ascidians, such as *Molgula batemani* and *Styela* sp. and bryozoans *Rhamphostomella*? sp. and *Bugula stolonifera* were also prominent. Scattered over the entire community were numerous *Mytilus* individuals from the 1979 spatfall that had grown to around 1 cm in length.

Changes in biomass (Fig. 7, curve B and C) and species numbers (Fig. 6, curve B and C) observed during the second and third twelve-month successional series were similar to those of the first twelve months of the study.

4. DISCUSSION

4.1 Monthly Immersion Series

The number of animal species that settled on monthly immersion panels showed an annual periodicity, with a peak in the warm months of spring and summer and settlement of few species in winter. Summer settlement is typical of temperate fouling sites with the reproduction of many organisms completely suppressed in winter periods [15]. The pattern shows some variation, however, with a low number of species settling in January 1979, compared to the high settlement rate during the same month in the previous two years.

Although the settlement of individual species showed marked seasonality, some anomalies were apparent. *Balanus trigonus* had an annual settlement peak during early autumn. In 1979, however, a second peak occurred during October, a month that had produced minimal settlement the previous two years. At the peak of settlement in 1977, over 300 spirorbid individuals settled per 100 cm^2 of panel surface, however maximum settlement in 1979 was less than 20 individuals per 100 cm^2. Physical factors such as salinity, temperature, light intensity and water quality are known to play a role in the settlement of fouling organisms [15]. Variations in one or more of these parameters may have created the variable settlements of the fouling organisms noted above. Some species, including *Balanus trigonus* settled continually but in variable numbers throughout the year. Skerman [16] attributed peaks in settlement of the barnacle *Elminius modestus* to periodic increase in the survival of the free living nauplius stage which was dependant primarily upon food availability. Food availability, which would lead to an increased number of individuals that achieved sessile status may have similarly controlled settlement rates of species such as *Balanus trigonus* in Careening Bay.

Reproductive activity of *Mytilus edulis* was inhibited by the high summer temperatures, as gametic development only occurs when the temperature falls below 21°C [17]. The water temperature at HMAS STIRLING drops below 21°C around April [14], and as reproductive maturation takes around 3 months [17], spawning and spatfall occurred during winter.

Mussel spat were far less numerous on monthly immersion panels than on panels from the successional series (Fig. 5).

Investigations have indicated that smooth surfaces attract fewer mussel spat when compared to roughened panels or filamentous materials [18-20]. In this study mussels were abundant on the roughened texture afforded by established organisms on the successional series, but were sparse on the relatively bare monthly immersion panels. Chalmer [13] observed substantial settlement of mussel spat on newly immersed asbestos panels, and attributed the low numbers of spat on smooth surfaces in other studies to mortality and migration of spat subsequent to settlement.

It is uncertain whether the low abundances of *Mytilus* spat found on the smooth panels in this investigation were due to reduced settlement or a failure of settled spat to persist.

4.2 Community Development

The fouling community on artificial substrate in Careening Bay progressed through the following developmental stages:

1. Heavy summer settlement of small opportunistic organisms which matured rapidly,

2. Settlement and growth of larger, less numerous, organisms which eventually overgrew pioneer colonisers,

3. Annual winter settlement of *Mytilus edulis* which grew to cover established fouling,

4. A periodic drop in fouling biomass as numerous large individuals and the attached fouling were lost from the community, and

5. Annual summer settlement of many species onto bare spaces and larger established organisms.

The development of the community was therefore dependent upon the temporal sequence of settlement and growth of organisms. The structure of the established community changed as a result of the periodic loss of mature *Mytilus* and other large solitary organisms. These organisms may have reached a size that could no longer be supported by their attachments. Alternatively, their loss may have been due to predation or the animals having reached the end of their life span [13]. The spaces created by the loss of these organisms were colonised by new settlement. Most species settled during the warm summer months, although the annual winter influx of *Mytilus* ensured that the mussel maintained a dominant position in the fouling community. The process of the loss of larger forms and recruitment of new individuals is continuous. The mature fouling community is therefore subject to continual change, although the changes occur in a regular, predictable manner. The community structure is dominated by a persistent assemblage of species whose abundances fluctuate annually.

The rock facings and old pilings in Careening Bay are dominated by *Mytilus* plus several ascidian and algal species [11] which suggests that the community that developed during the panel trial was representative of other submerged surfaces in the region. The absence of algae from the panels was due to shading by the wharf.

Wilson and Hodgkin [17] also noted a periodic fall-off of mature mussels from the fouling community at Coogee, Western Australia. The fouled surface could only hold a certain number of adult mussels and the fall-off was regarded as an emigration of individuals resulting from population pressure. Similar situations have been reported for other fouling communities. The solitary ascidian, *Styela plicata* underwent an annual autumn slough-off from a fouling community in Beaufort, North Carolina [21]. The slough-off, together with annual recruitment, produced dramatic annual changes to the community so that a stable climax stage would never be reached [22]. Saenger *et al.* [8] noted a slough-off of parts of fouling communities in two North Queensland rivers. Water movement and the death of underlying organisms caused the slough-off and the resultant bare patches were rapidly colonised. The mature community consisted of areas of different aged growths, a condition typical of natural substrates in the area.

4.3 Comparison with Other Australian Regions

The marine fouling community that developed in Careening Bay contained several species that are prevalent in other temperate regions of the Australian coast. The barnacle *Balanus variegatus*, bryozoans *Bugula neritina* and *Cryptosula pallasiana* and tubeworm *Hydroides elegans* have been recorded in fouling studies in Hobsons Bay, Victoria, and Sydney Harbour, New South Wales [10,23]. The mussel *Mytilus edulis* was prominent in Careening Bay and has been similarly observed to dominate mature communities in areas of Sydney Harbour [5] and Hobsons Bay [24].

Differences that occur between the fouling at various regions can be seen from a comparison of the dominant species in Careening Bay with those from the east Australian coast sites (Table 2). No one species was a prominent contributor to the fouling community at all sites.

The dry weight of fouling in Careening Bay reached a peak of 6.7 kg/m^2 after twenty-two months development (Fig. 7). The subsequent decline has been discussed. The average biomass for the three twelve-month successional series was 2.7 kg/m^2 (Fig. 8). This is much less than the 8.3 kg/m^2 obtained on panels after one years immersion at the Garden Island Naval Dockyard, New South Wales [10]. The biomass of the fouling that developed on panels in Williamstown Naval Dockyard in Hobsons Bay, Victoria, during 1974 was 1.2 kg/m^2 [10], and a recent study by the Materials Research Laboratories at a nearby site in Williamstown Naval Dockyard recorded 0.3 kg/m^2 after twelve months [25]. These figures indicate that the biomass of fouling at HMAS STIRLING is intermediate to those at Garden Island Naval Dockyard and Williamstown Naval Dockyard.

5. CONCLUSIONS

1. Marine fouling species in Careening Bay showed marked temporal variation in both season and abundance of settlement. Settlement of most species peaked during the summer months when water temperatures were highest.

2. The fouling community developed in several stages dependent upon succession of species settlement, and growth of organisms.

3. The established fouling community underwent annual changes due to a summer influx of numerous species, the late winter settlement of *Mytilus* and the periodic loss of large, mature organisms.

4. The dominant marine fouling species at HMAS STIRLING were different to those prominant in the fouling at the east Australian Naval Establishments.

6. ACKNOWLEDGEMENTS

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TABLE 1

COMMON FOULING ORGANISMS IN CAREENING BAY

Species	Systematic Position
Scypha ciliata (Fabricius)	Calcarea, Porifera
Clathrina sp.	"
Campanularia sp.	Hydroida, Coelenterata
Obelia sp.	"
Bugula neritina (Linnaeus)	Cheilostomata, Bryozoa
Bugula stolonifera Ryland	"
Tricellaria sp.	"
Microporella coronata Audouin & Savigny	"
Cryptosula pallasiana (Moll)	"
Rhamphostomella? sp.	"
Polydora sp.	Spionida, Polychaeta
Filograna implexa Berkeley	Serpulida, Polychaeta
Hydroides elegans (Haswell)	"
Janua pagenstecheri (Quatrefages)	"
Ostrea sp.	Prionodesmacea, Mollusca
Anomia trigonopsis Hutton	"
Mytilus edulis (Linnaeus)	"
Balanus trigonus Darwin	Cirripedia, Crustacea
Balanus variegatus Darwin	"
Gammaridae spp.	Amphipoda, Crustacea
Trididemnum sp.	Enterogona, Ascidiacea
Ascidia aspersa (Muller)	"
Botrylloides leachii Savigny	Pleurogona, Ascidiacea
Symplegma viride Herdman	"
Styela sp.	"
Microcosmus claudicans Savigny	"
Molgula batemani Kott	"

TABLE 2

COMPARISON OF THE PRINCIPAL ANIMAL FOULING SPECIES FROM THREE AUSTRALIAN NAVAL ESTABLISHEMENTS

	HMAS STIRLING (WA)	GARDEN ISLAND NAVAL DOCKYARD (NSW)	WILLIAMSTOWN NAVAL DOCKYARD (VIC)
Barnacles	*Balanus trigonus*	*Balanus variegatus*	*Balanus variegatus*
			Elminius modestus
Ascidians	*Microcosmus claudicans*	*Pyura praeputialis*	*Ciona intestinalis*
	Styela sp.		
Molluscs	*Anomia trigonopsis*		*Mytilus edulis*
	Mytilus edulis		
Bryozoans	*Rhamphostomella?* sp.	*Watersipora subovoidea*	*Cryptosula pallasiana*
	Bugula stolonifera	*Bugula neritina*	*Bugula neritina*
		Schizoporella unicornis	

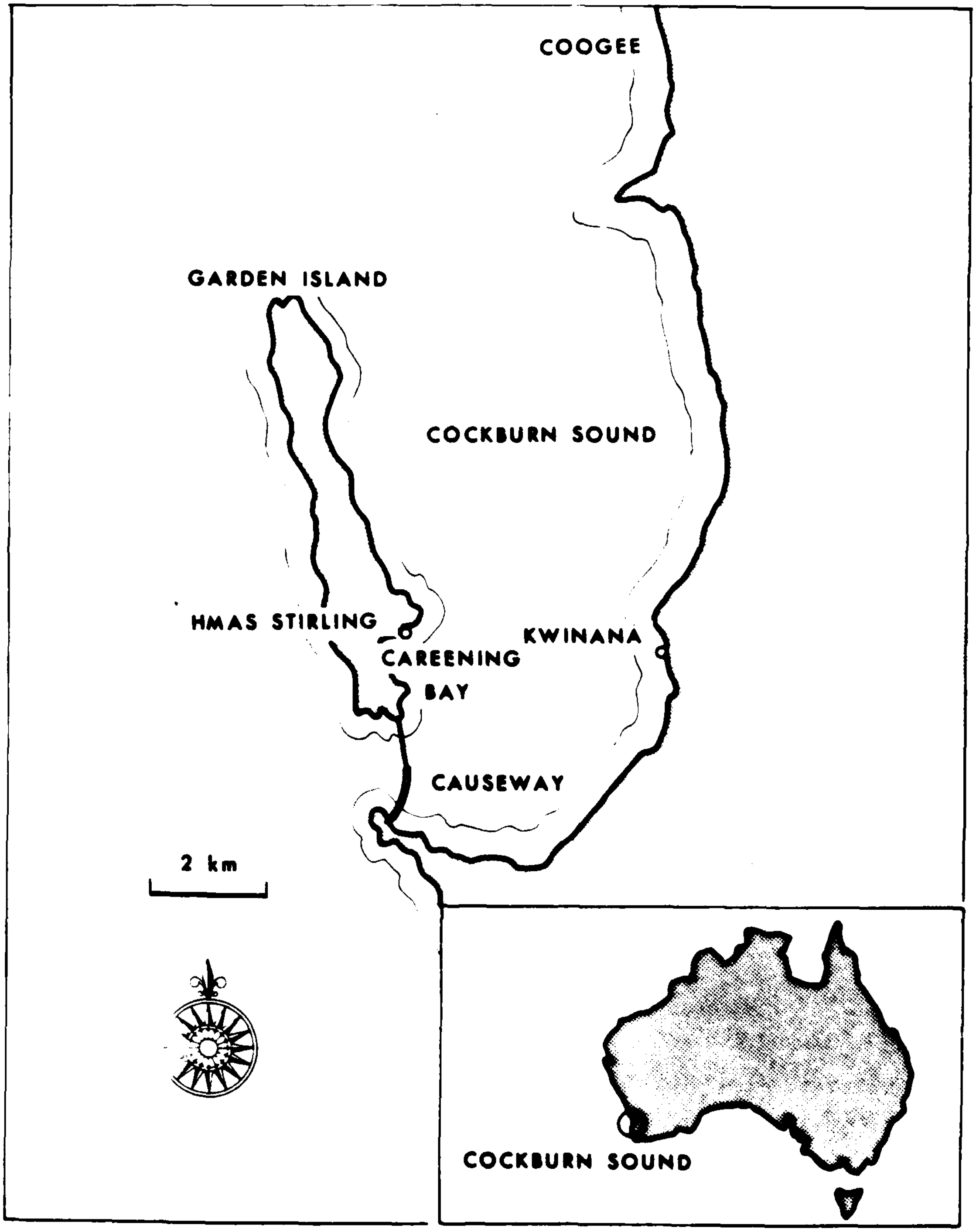

FIGURE 1 Locality diagram

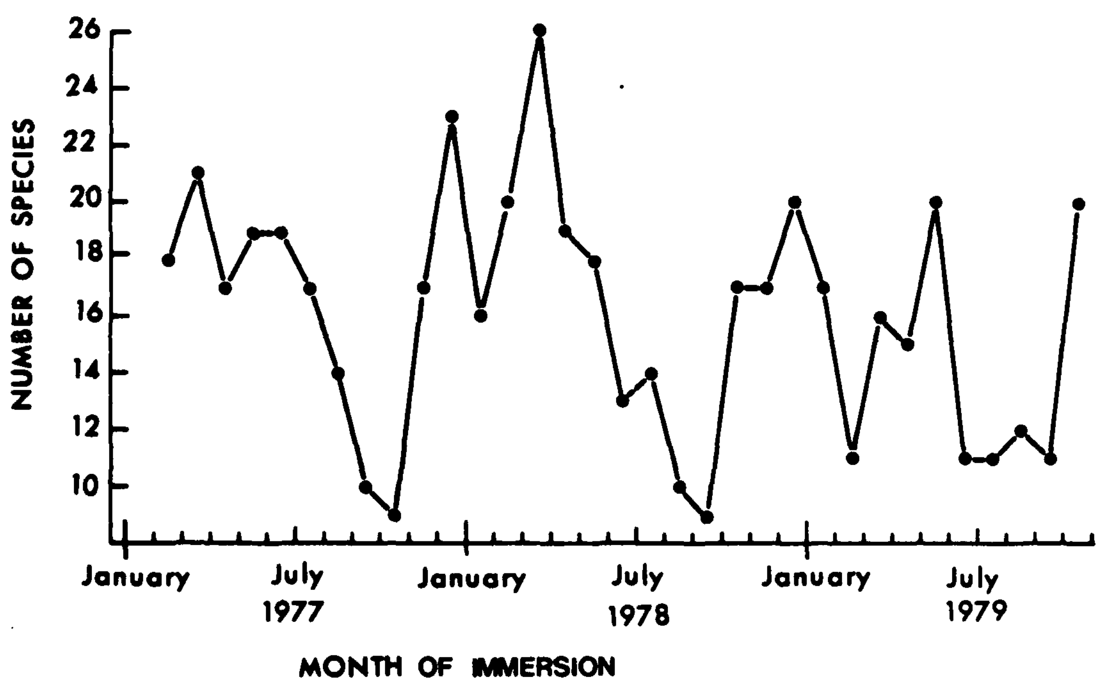

FIGURE 2   Number of sendentary species on monthly immersion panels

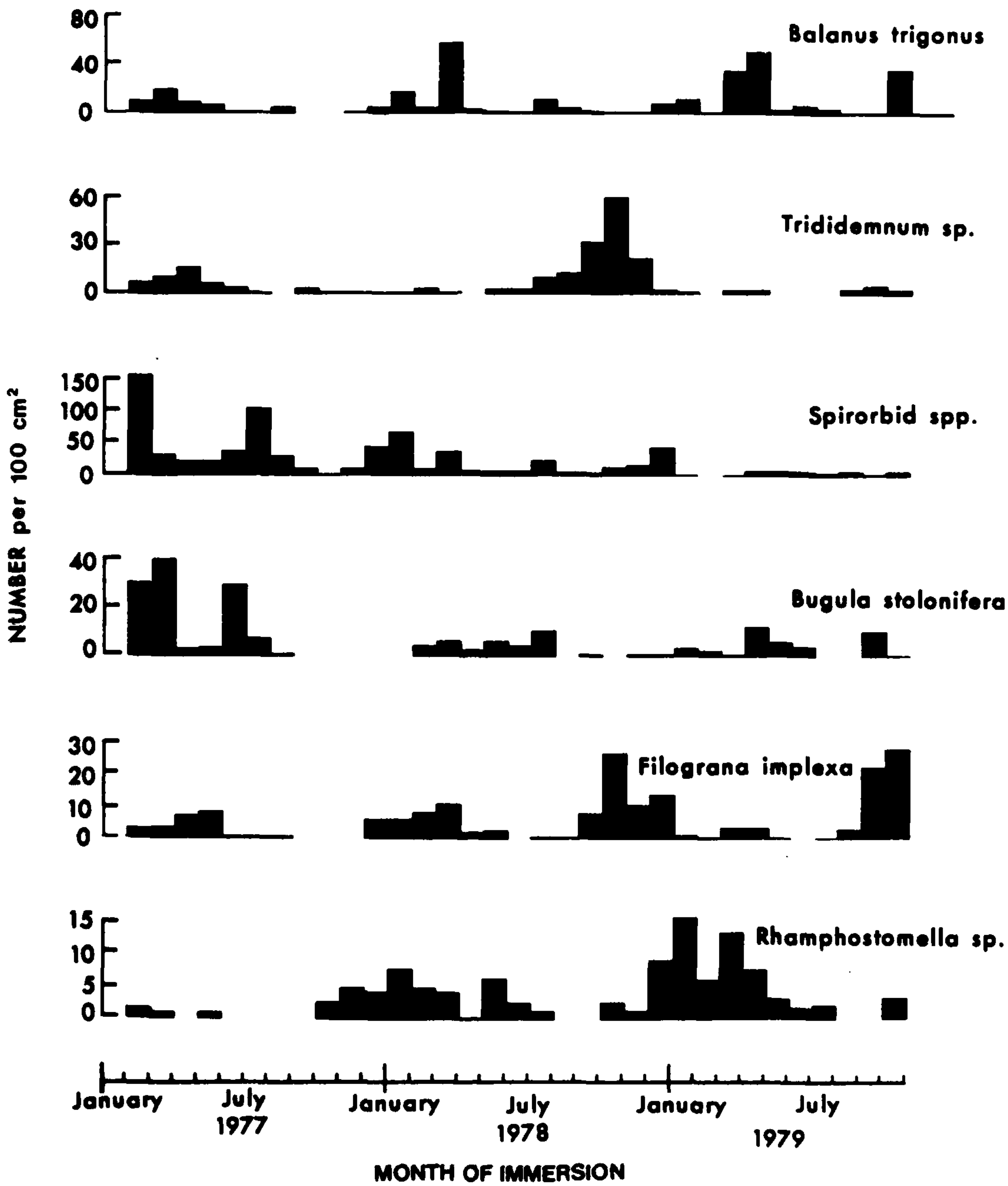

FIGURE 3 Seasonal variation in settlement of principal fouling organisms in Careening Bay

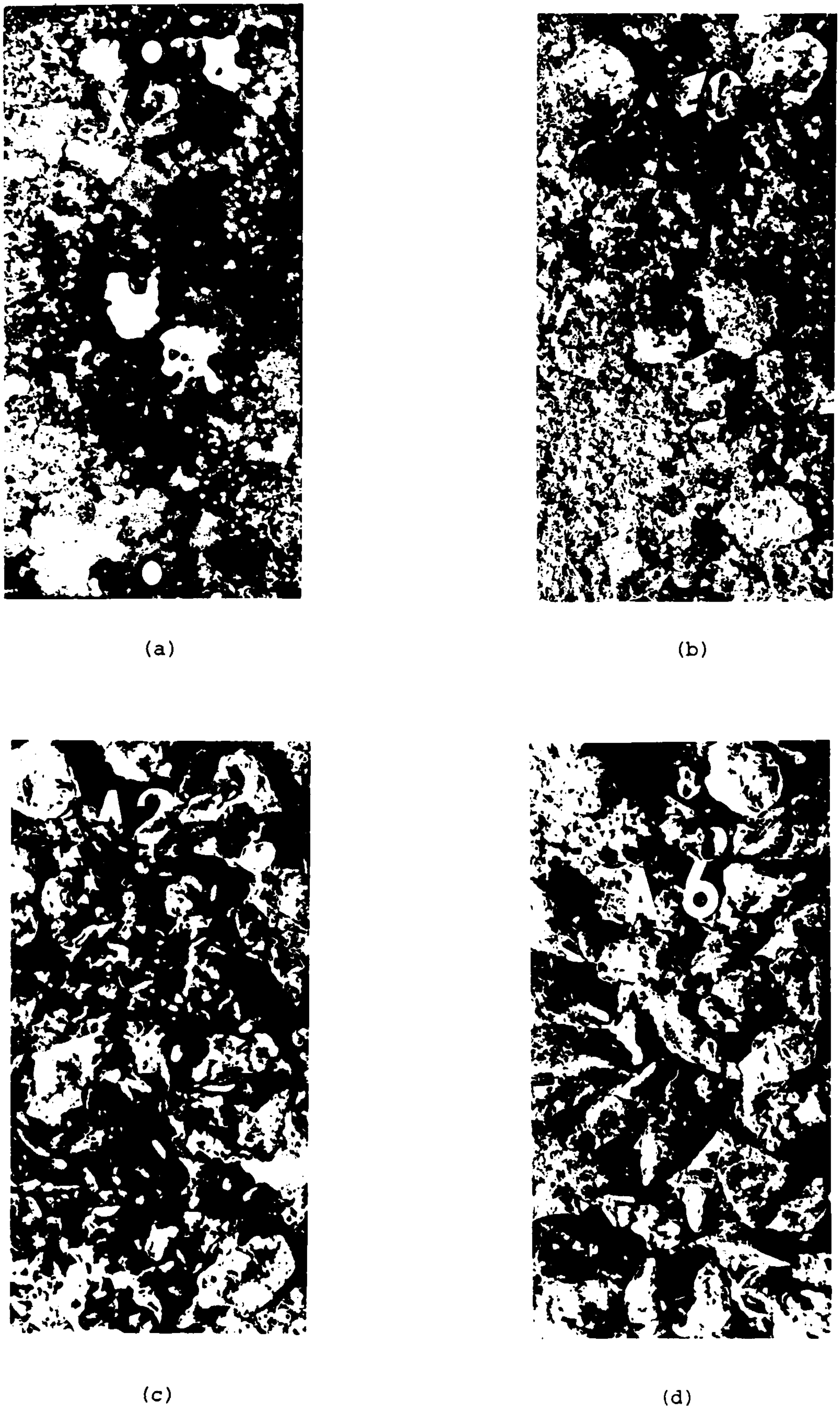

FIGURE 4 Development of marine fouling at HMAS STIRLING
A, 2 months; B, 10 months; C, 16 months; D, 24 months

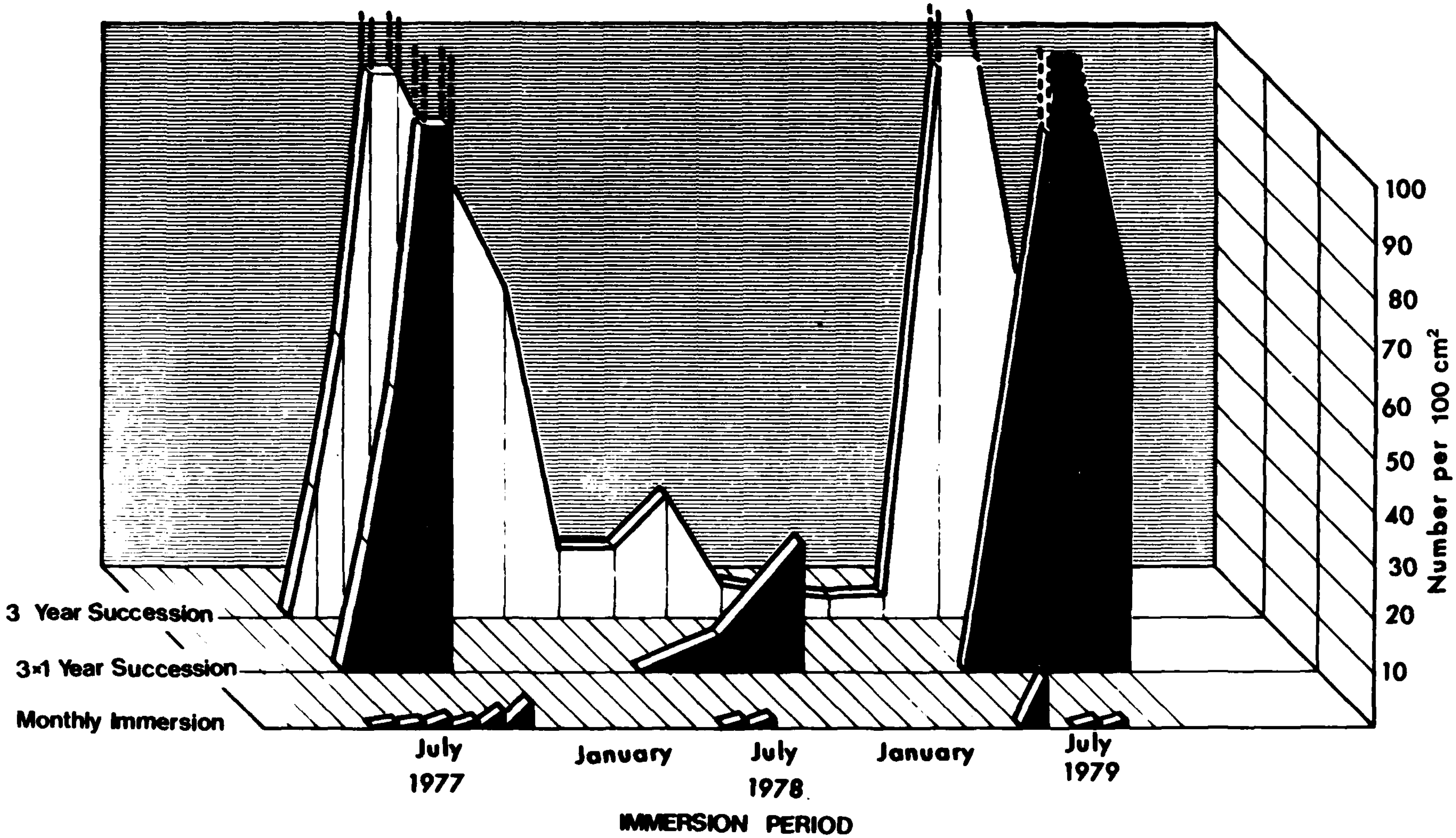

FIGURE 5 Changes in abundance of *Mytilus edulis* on monthly immersion, short-term successional and long-term successional series with time.

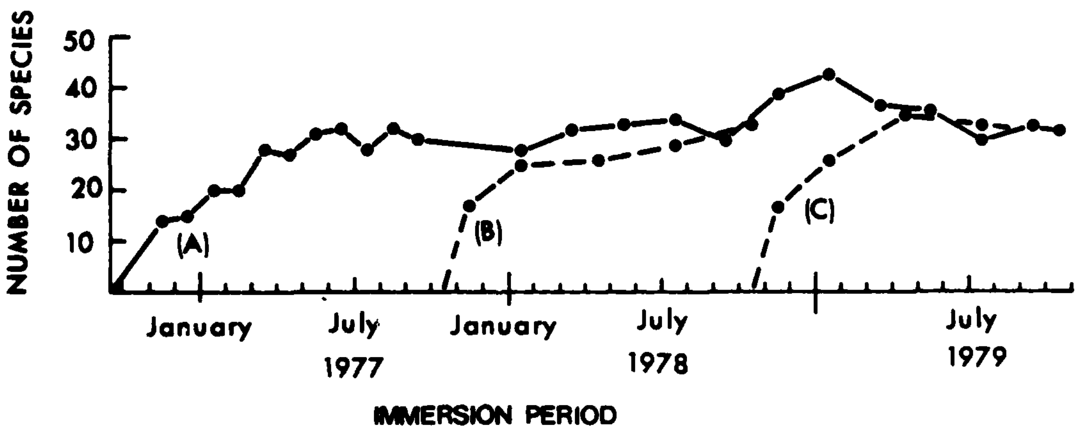

FIGURE 6   Number of sedentary species on successional panels

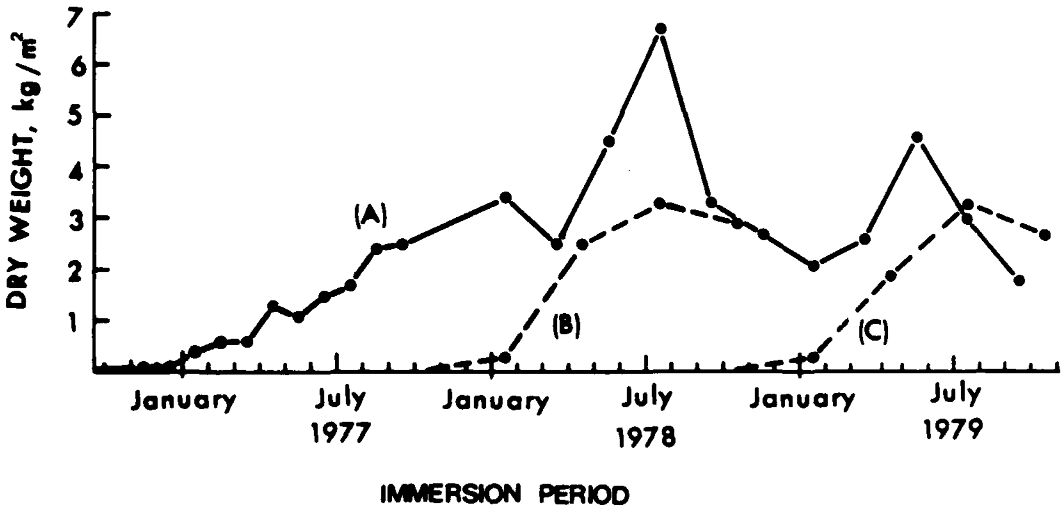

FIGURE 7 Changes in fouling biomass of successional panel series with time

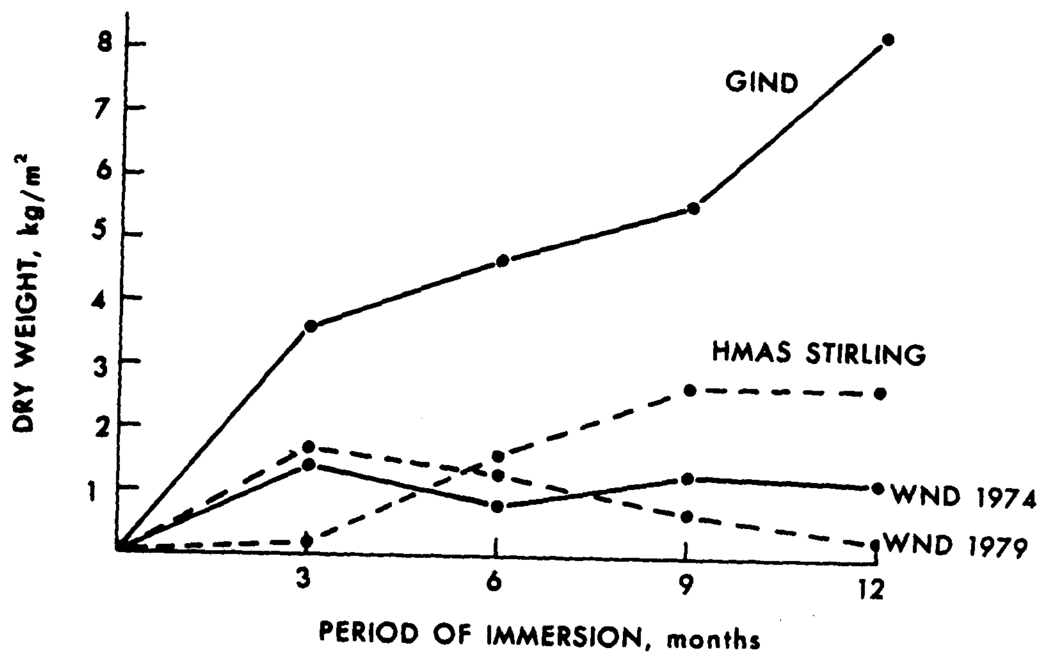

FIGURE 8 Changes in dry weight of fouling with time at Garden Island Naval Dockyard (GIND) [10], Williamstown Naval Dockyard (WND) for 1974 [10] and 1979 [25] and HMAS STIRLING

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